

**SSC18-WKII-01****Frequency and Legal Regulations Surrounding a Ground Station Network**

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**ABSTRACT**

The small satellite community is presently facing an issue regarding UHF band frequency usage. There is currently an effort to establish limits on the strength of the waves for the bands Uplink: 401-403 MHz and Downlink 460-470 MHz. Once this rule is officially approved in the ITU, the only other remaining option is 449.75-450.25 MHz for uplink. However, these bands are only treated as side notes, and there is no guarantee that they can definitely be used. With regards to amateur radio bands, there are fundamental disagreements with the idea of using amateur radio frequencies for satellite TT&C. As a result, it will become functionally impossible to use those frequencies for satellite uplink. Maintaining usage of UHF band frequencies is important for the development of the satellite industry. If unable to use UHF frequencies, there remains no other option but to use high frequency bands. For instance, if a country wanted to begin satellite development, and they were in a situation where they had no choice but to use S/X/Ka band frequencies, this would be a significant barrier to entry. Overall, there is a need to make the community's voice heard in the ITU.

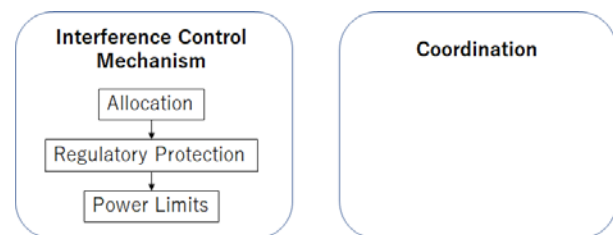
**1. INTRODUCTION**

In order to realize a ground station network, one must consider not only the technical challenges but also the problems of international frequency coordination and legal restrictions. The issue of which frequency to use is a particularly large topic, which the small satellite community is presently facing with regards to UHF band frequency usage. In particular, several restrictions are being imposed on frequencies allocated to space communication from lobbying groups, such as uplink transmission power (e.g. for frequencies like 401 ~ 403 MHz). There is also the possibility of these restrictions being imposed on other bands in the future. The small satellite community needs to understand the international frequency allocation and coordination system organized by the International Telecommunication Union (ITU). It is a competition to keep or get frequencies.

**2. ITU INTERFERENCE CONTROL MECHANISM AND COORDINATION**

If everyone used any frequency they wanted, we wouldn't be able to stop radio interference, which makes it very difficult to secure communication. Therefore, the ITU sets rules to control interference. It is very important to understand these ITU rules, which are called Radio Regulations (RR).

There are two main things to understand: interference control mechanism and coordination.

**Figure 1: ITU Frequency Coordination Principles**

The ITU defines frequency allocation, regulatory protection, and power limits to control radio interference. Basically, all radio service providers need to follow this mechanism to avoid interference. But this is not enough to avoid all interference. In addition, every radio service provider needs to coordinate their frequency use with others.

**2.1. RR Structure**

The interference control mechanism is written and published as the RR. It consists of four volumes.

- Volume 1 – Articles

This volume is the main part of the RR. It mainly covers three components of the interference control mechanism: frequency allocation, regulatory protection, and power limits. This volume also includes principles of frequency coordination and radio service definition.

- Volume 2 – Appendices

This volume includes supporting information for the RR, especially information of a technical nature.

- Volume 3 – Resolutions and Recommendations

This volume includes revisions to the RR. Every 2 to 4 years, the World Radiocommunication Conferences (WRC) is held and the RR is revisited and revised. This volume includes regulatory protection and power limits for specific topics that require attention.

- Volume 4 – ITU-R Recommendations incorporated by reference

This volume includes reference information regarding interference mitigation and frequency coordination.

## 2.2. Principles and General Coordination Rules

Someone who wants to use a space service frequency needs to understand the following principles and general coordination rules.

- Radio frequencies and any associated orbits, especially the geostationary satellite orbit, are limited natural resources.
- Therefore, any radio service operator needs to try to limit the number of frequencies and the spectrum used to the bare minimum to provide their necessary services in a satisfactory manner.
- Any new assignment, any change of frequency, or any other basic characteristic of an existing assignment must avoid causing harmful interference to other services.

## 2.3. Frequency Allocation

Frequencies are separated by stations of different services. Each frequency band includes one or more terrestrial or space radiocommunication services or the radio astronomy service. It is not allowed to use a band for undefined services. The world has been divided into three regions and each region has different frequency allocation. It is more difficult to use a worldwide ground station network if each region has a completely different service allocation. Fortunately, all three regions tend to have the same service allocation for satellite-related services. Table 1 shows an example of a frequency allocation table.

**Table 1: 410-440 MHz Frequency Allocation**

Region 1	Region 2	Region 3
<b>410-420</b> FIXED MOBILE except aeronautical mobile SPACE RESEARCH (space-to-space) 5.268		
<b>420-430</b> FIXED MOBILE except aeronautical mobile Radiolocation 5.269 5.270 5.271		

<b>430-432</b> AMATEUR RADIOLOCATION 5.271 5.274 5.275 5.276 5.277	<b>430-432</b> RADIOLOCATION Amateur 5.271 5.276 5.278 5.279
<b>432-438</b> AMATEUR RADIOLOCATION Earth exploration-satellite (active) 5.279A 5.138 5.271 5.276 5.277 5.280 5.281 5.282	<b>432-438</b> RADIOLOCATION Amateur Earth exploration-satellite (active) 5.279A 5.271 5.276 5.278 5.279 5.281 5.282
<b>438-440</b> AMATEUR RADIOLOCATION 5.271 5.274 5.275 5.276 5.277 5.283	<b>438-440</b> RADIOLOCATION Amateur 5.271 5.276 5.278 5.279

## Radio Services

A radiocommunication service is a service involving the transmission and/or reception of radio waves for specific telecommunication purposes. Because frequency allocation defines the permitted services, the satellite operator must choose their service carefully and accurately. If the wrong service is written in an application, it might be rejected.

Some commercial CubeSats and small satellites are currently using amateur radio frequencies because the first CubeSats launched also did so. This has been accepted thus far, but we need to revisit these principles. Amateur frequencies must be used for amateur radio services. The following shows some service definitions from the ITU RR.

- amateur service: A radiocommunication service for the purpose of self-training, intercommunication and technical investigations carried out by amateurs, that is, by duly authorized persons interested in radio technique solely with a personal aim and without pecuniary interest. (From RR Volume 1, Article 1, 1.56)
- amateur-satellite service: A radiocommunication service using space stations on earth satellites for the same purposes as those of the amateur service. (From RR Volume 1, Article 1, 1.57)
- space operation service: A radiocommunication service concerned exclusively with the operation of spacecraft, in particular space tracking, space telemetry and space telecommand. (From RR Volume 1, Article 1, 1.23)

- Earth exploration-satellite service: A radiocommunication service between earth stations and one or more space stations, which may include links between space stations, in which: – information relating to the characteristics of the Earth and its natural phenomena, including data relating to the state of the environment, is obtained from active sensors or passive sensors on Earth satellites; – similar information is collected from airborne or Earth-based platforms; – such information may be distributed to earth stations within the system concerned; – platform interrogation may be included. This service may also include feeder links necessary for its operation. (From RR Volume 1, Article 1, 1.51)

We must note that “amateur service” is defined as a terrestrial radiocommunication and that it is different from an “amateur-satellite service.”

#### 2.4. Regulatory Protection

There are special regulatory protections for specific applications. Those regulatory protections exist as an article or a resolution. Below are a few examples that satellite operators should know.

- Geostationary-satellite is given priority over non-geostationary-satellite. Non-geostationary-satellite shall not cause unacceptable interference to and shall not claim protection from geostationary-satellite networks. (Summarized from RR Volume 1, Article 22, 22.2)
- Data collection systems (DCS) need to have stable regulatory certainty for long-term continuity for its operation. The establishment of power limits for earth stations is necessary. (Summarized from RR Volume 3, RESOLUTION 765 and 766 (WRC-15))

#### 2.5. Power Limits

There are three types of power limits to control interference.

- Power Flux-Density (PFD) to protect terrestrial services from space services.
- Equivalent Isotropically Radiated Power (EIRP) to protect space services from terrestrial services.
- Aggregate Equivalent Power Flux-Density (EPFD) to protect geostationary-satellite services from non-geostationary-satellite services.

Power limits appears in articles and resolutions. Below are a few examples that satellite operators should know.

- The power flux-density at the Earth’s surface produced by emissions from a space station, including emissions from a reflecting satellite, for all conditions and for all methods of modulation, shall not exceed the limit given in Table 21-4. (From RR Volume 1, Article 21, 21.16)
- In the frequency band 8025-8400 MHz, which the Earth exploration-satellite service using non-geostationary satellites shares with the fixed-satellite service (Earth-to-space) or the meteorological-satellite service (Earth-to-space), the maximum power flux-density produced at the geostationary-satellite orbit by any Earth exploration-satellite service space station shall not exceed –174 dB(W/m<sup>2</sup>) in any 4 kHz band. (Extracted from RR Volume 1, Article 22, 22.5)

#### 2.6. Coordination

Interference is controlled by coordinating radio communication operation between radio administrators in each country. Coordination is handled through a system called the International Frequency Information Circular (IFIC) of the ITU Radiocommunication Bureau (BR). The administrator in each country sends the information on the radio stations that needs to be coordinated to the BR, which waits for the opinion from other countries before beginning coordination. Details on the adjustments are described in Article 9 of the RR.

### 3. RR REVISION

The ITU and member countries hold World radiocommunication conferences (WRC) every two to four years. The main purpose of the WRC is to review and revise the RR. Radiocommunication technology and radio usage trends are changing. Frequency allocation needs to be changed to adapt to the latest situation. Last, lobbying groups are given the chance to initiate discussions for revision.

#### 3.1. UHF Allocation Review in WRC-19

Below are the possible UHF 400MHz band allocations for satellite operation, not including amateur frequency.

- Uplink: 401-403 MHz, 449.75-450.25 MHz
- Downlink: 400.15-402 MHz, 460-470 MHz

Among these, there is currently an effort to establish limits on the strength of the waves for the bands Uplink: 401-403 MHz and Downlink 460-470 MHz. In the event that these limits are not upheld, the applications for those frequencies will not be recognized. In order to uphold the limits, both satellites and ground stations must be able to transmit weak

waves. If there is an issue using uplink bands 401-403 MHz, the only remaining option is 449.75-450.25 MHz. However, these bands are only treated as foot notes, not first or second frequency allocations, which means that operators must use a document called Coordination Request (CR) to use this frequency. Because the CR process is more technical and complicated than API (Advance Publication Information) coordination, use of UHF 400MHz frequencies for satellite telecommands becomes another barrier to first-time operators.

While CR coordination is more difficult, maintaining usage of UHF band frequencies is important for the development of the satellite industry. If we are unable to use UHF frequencies, there remains no other option but to use high frequency bands. For instance, if a country wanted to begin satellite development, and they were in a situation where they had no choice but to use S/X/Ka band frequencies, this would:

- Raise the technological requirements and hardware cost on the satellite end
- Require the usage of a parabola antenna at the ground station, thus increasing costs on the ground station end

Both of these are significant barriers to entry and would have an overall negative effect on the satellite industry as a whole.

#### **4. SUMMARY**

There is a need to make the community's voice heard in the ITU. Any satellite operator who wants to get and keep a frequency needs to aware that their voice should be heard in the ITU via each country's radio authority. A few years from now, the current frequency allocations may be different. If CubeSats and the small satellite community continue to use amateur frequencies without a long-term strategy, we may lose other frequency bands can be used. In addition, this community needs to understand ITU regulations and use frequencies properly. Following regulations and talking with other communities will give the community their right to voice their opinion to the ITU.

#### ***References***

1. International Telecommunication Union, "Radio Regulations".